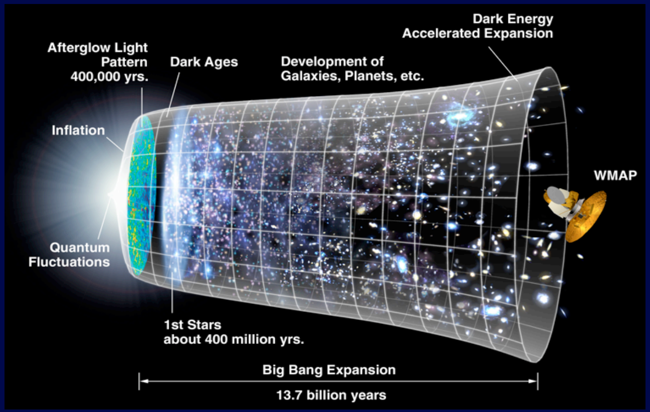
Future Visible/NIR Cosmology Surveys

Alexandre Refregier (CEA Saclay)
+ Euclid Collaboration

Great Surveys Workshop - Santa Fe - Nov 2008

Cosmology Surveys



Cosmology: Open questions
Dark Energy
Dark Matter
Gravity
Initial conditions (Inflation?)
→ Look for new Physics

Physical quantities:
distance measures, growth rate, clustering statistics
several fields: potentials, density, velocity

Cosmological Probes:
Weak Lensing, BAO, Supernovae, Clusters, ISW, z-distortions, etc

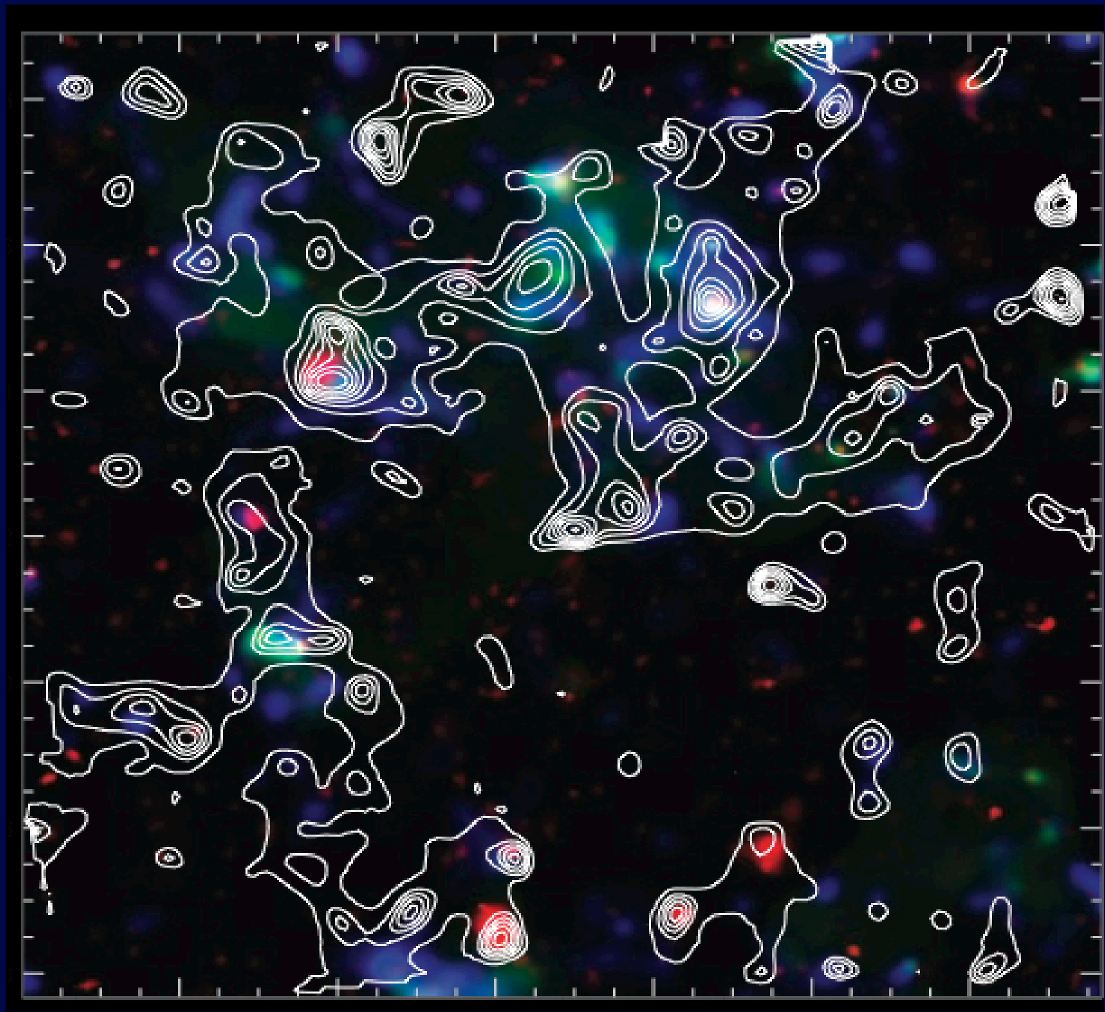
Observational Resources:
Imaging (shape measurement)
Multi-band photometry
Spectroscopy
→ optimise surveys and distribute between ground and space

Future Vis/NIR Instruments

Survey	Diameter (m)	FOV (deg^2)	Area (deg^2)	start
CFHTLS	3.6	1	172	2003
KIDS (VST)	2.6	1	1700	2008
DES (NOAO)	4	2	5000	2011
HSC (Subaru)	8	2	2000?	2011
Pan-STARRS	1.8(x4)	4(x4)	20000	2007(12)
LSST	8.4	7	20000	2014
Euclid	1.2 space	1	20000	2017
JDEM	1.4?space	?	?	2015

+ Spectroscopy: BOSS, WFMOS, LAMOST, HETDEX, etc

Weak Gravitational Lensing



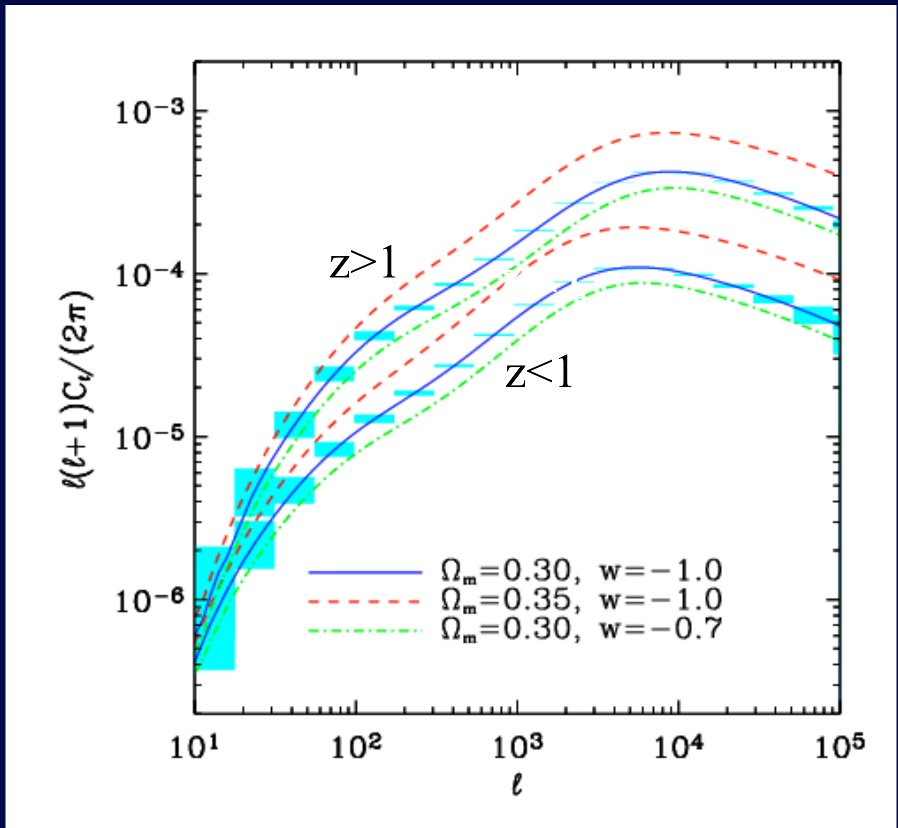
COSMOS ACS survey

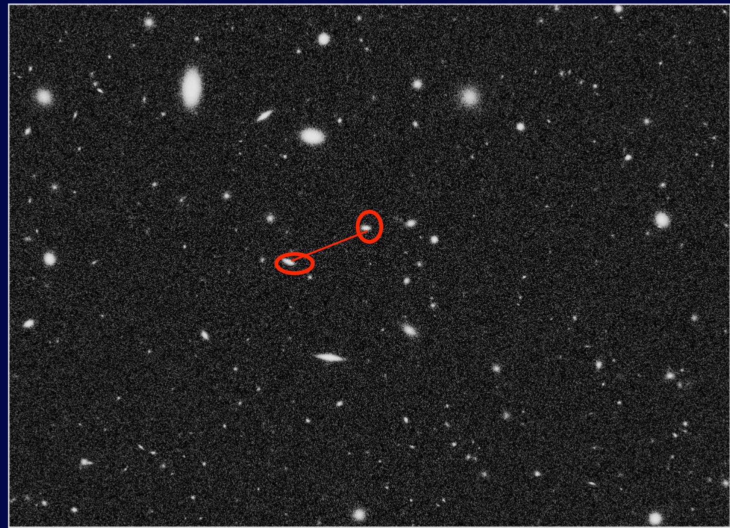
Massey et al. 2006, Nature cover

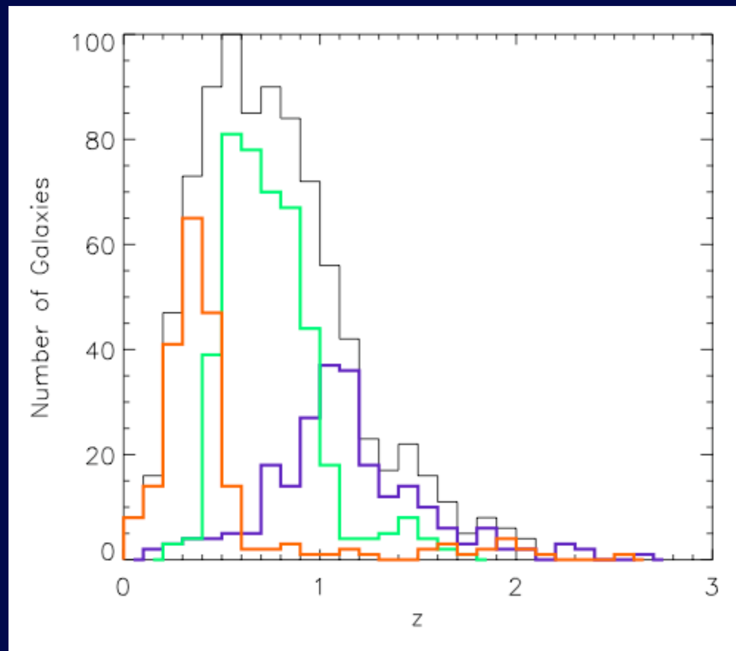
Weak Lensing Tomography

Wide Survey: 20,000 deg^2,
40 galaxies/amin^2, z_m=0.9, ground-based complement for photo-z's

WL power spectrum for each z-bin





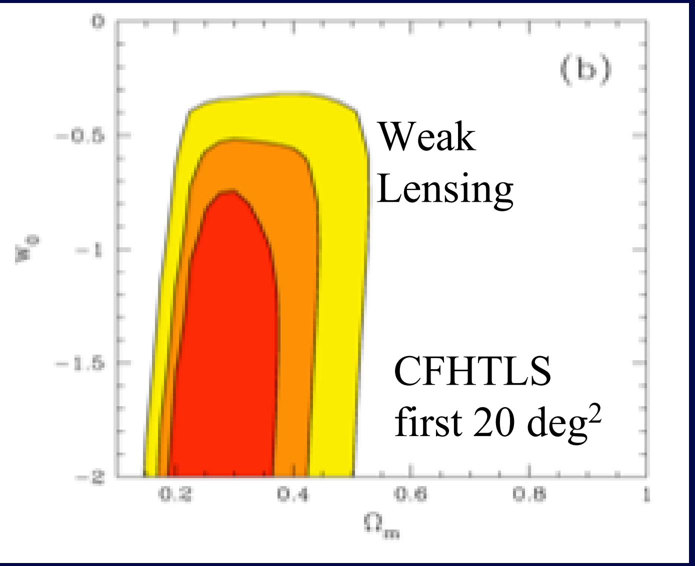


Current DE Constraints

Current constraints: 10-20% on constant w

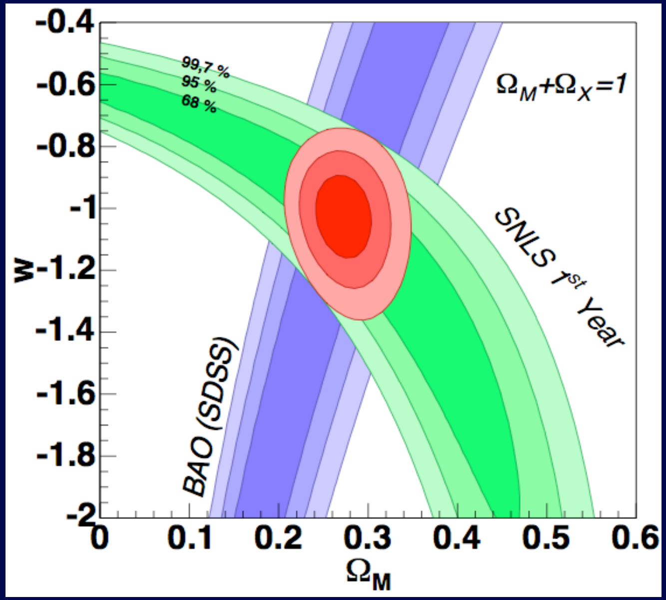
For definite answers on DE: need to reach a precision of 1% on (varying) w and 10% on w'

Hoekstra et al. 2005

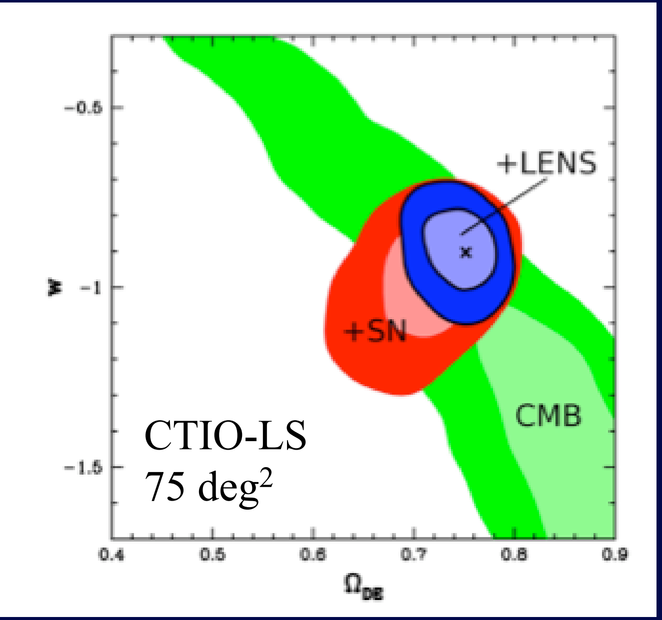


Comparison with Other Probes

Astier et al. 2005



Jarvis et al. 2006

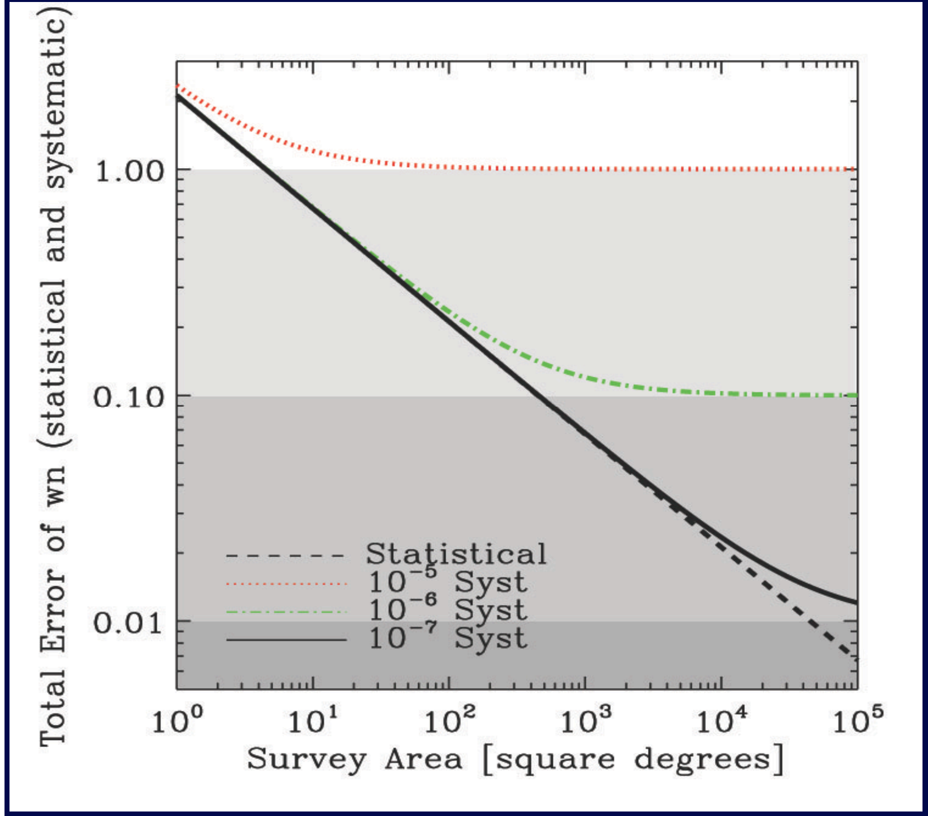


Requirements for Weak Lensing

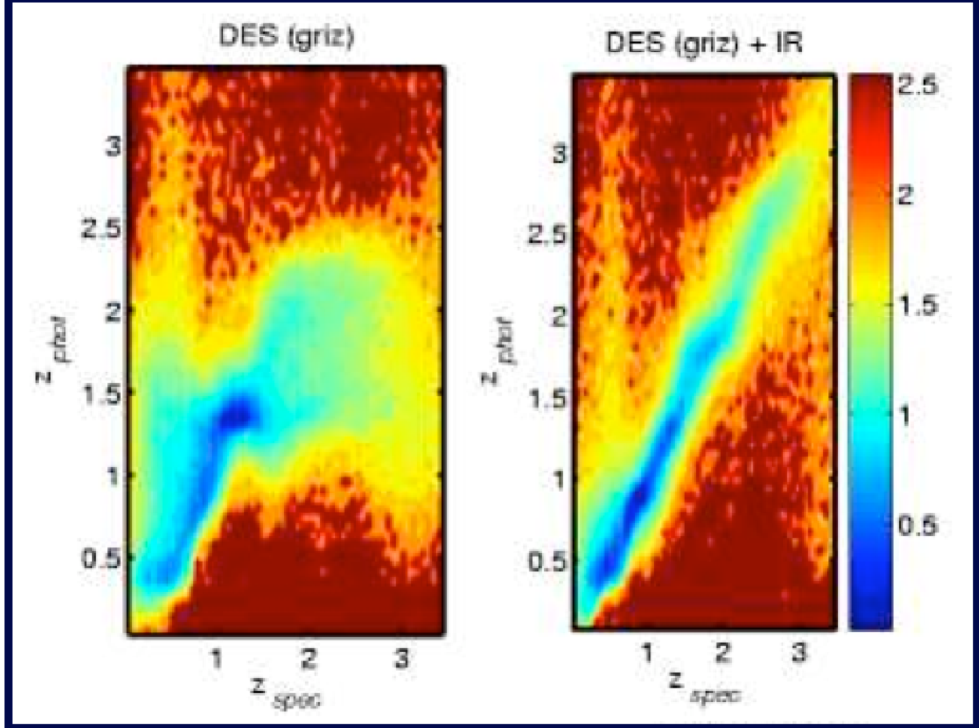
Statistics: optimal survey geometry: wide rather than deep for a fixed survey time, → need 20,000 deg^2 to reach ~1% precision on w

Redshift bins: need good photo-z to make redshift bins and to correct for intrinsic alignements → need IR

Systematics: Need to gain 2 orders of magnitude in systematic residual variance → need about 50 bright stars to calibrate PSF



Amara & Refregier 2007, 2008



Abdalla et al. 2007

Euclid

EUCLID

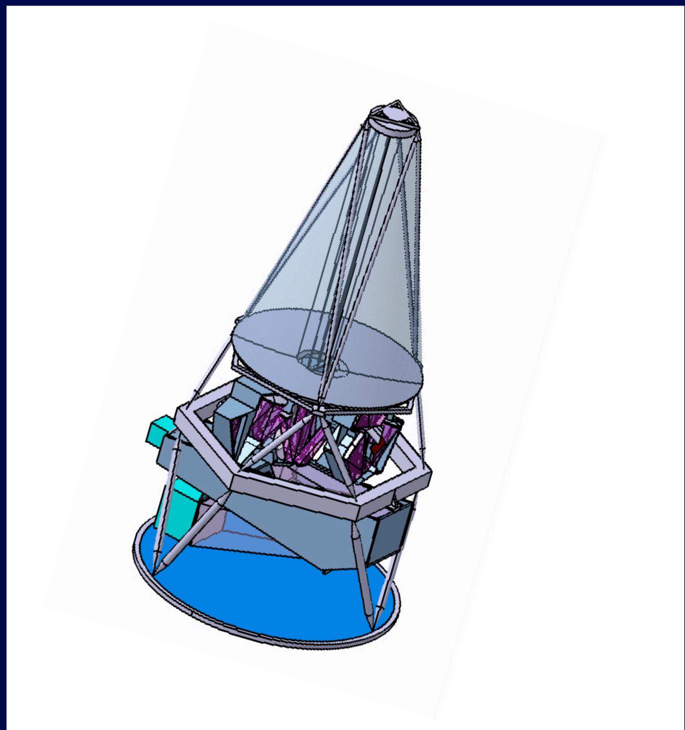
ESA’s All-sky Mission to Map the Geometry of the Dark Universe

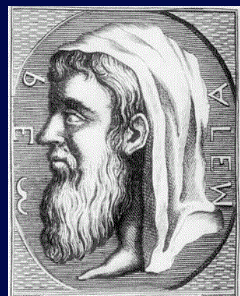
Primary Science Goals: Cosmology:

- nature of the dark energy
- nature of the dark matter
- initial conditions (inflation?)

Gravity

→ Secondary goals: Legacy science





Cosmological Probes

EUCLID

PI: A. Refregier

PI: A. Cimatti

Primary probes:

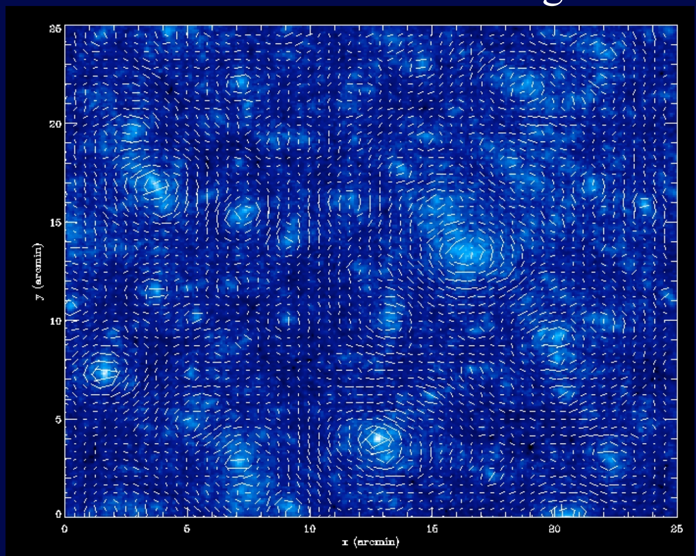
with all-sky Vis+NIR imaging and spectroscopic survey

- Weak Lensing
- Baryonic Accoustic Oscillations

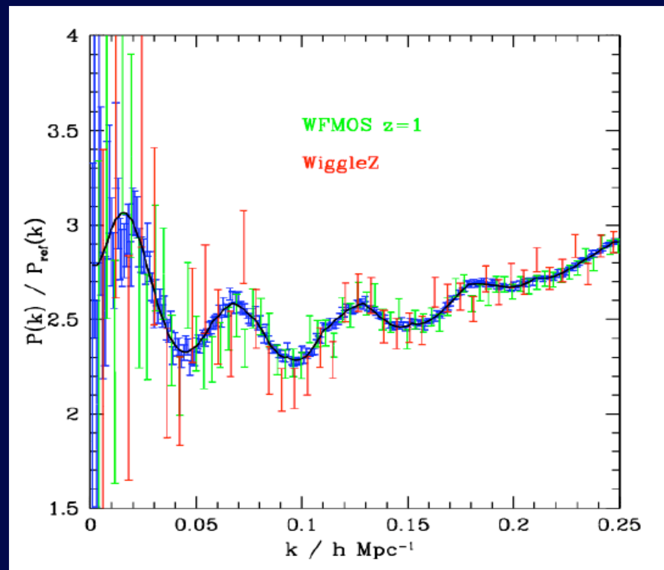
Additional Probes:

- Clusters Counts
- Galaxy clustering (full P(k))
- Redshift space distortions
- Integrated Sachs-Wolfe Effect (correlation with CMB)

Weak Lensing



BAO



Euclid Mission Implementation

EUCLID

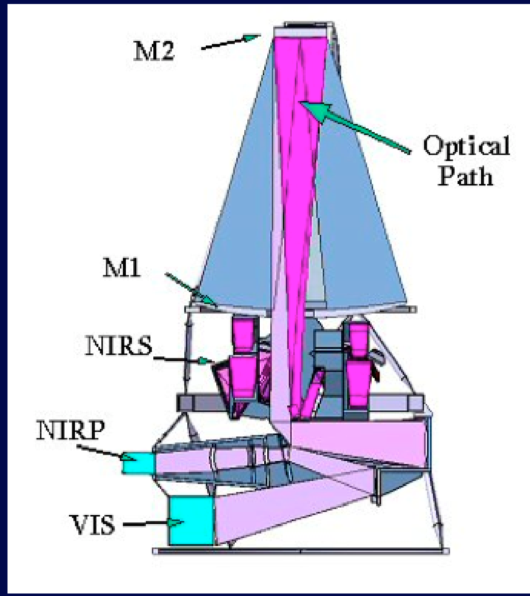
Mission elements:

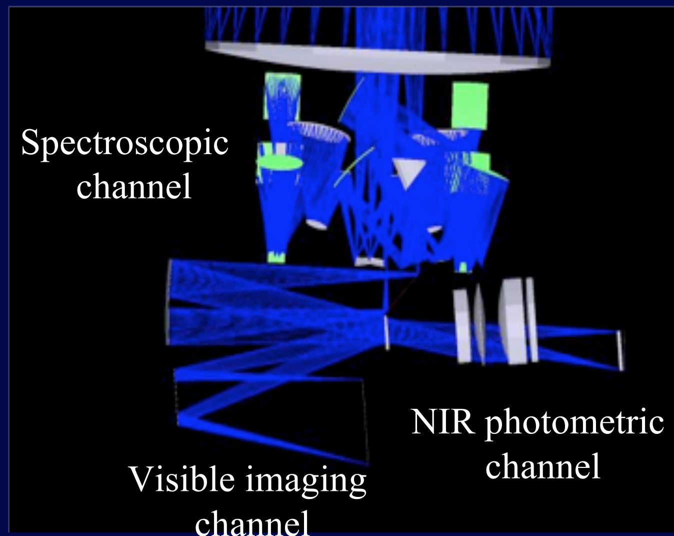
- L2 Orbit
- 4-5 year mission
- Data rate Max 700 Gbits/day (compressed)
- Telescope: three mirror assembly (TMA) with 1.2 m primary
- Instruments:

– Visible imaging channel: 0.5 deg^2, 0.10’’ pixels, 0.23’’ PSF FWHM, broad band R+I+Z (0.55-0.92mu), CCD detectors, galaxy shapes

– NIR photometry channel: 0.25-0.5 deg^2, 0.3’’ pixels, 3 bands Y,J,H (1.0-1.7mu), HgCdTe detectors, Photo-z’s

– NIR Spectroscopic channel: 0.25-0.5 deg^2, R=400, 0.9-1.7mu, slits with DMD (backup: slitless), redshifts





Euclid Surveys

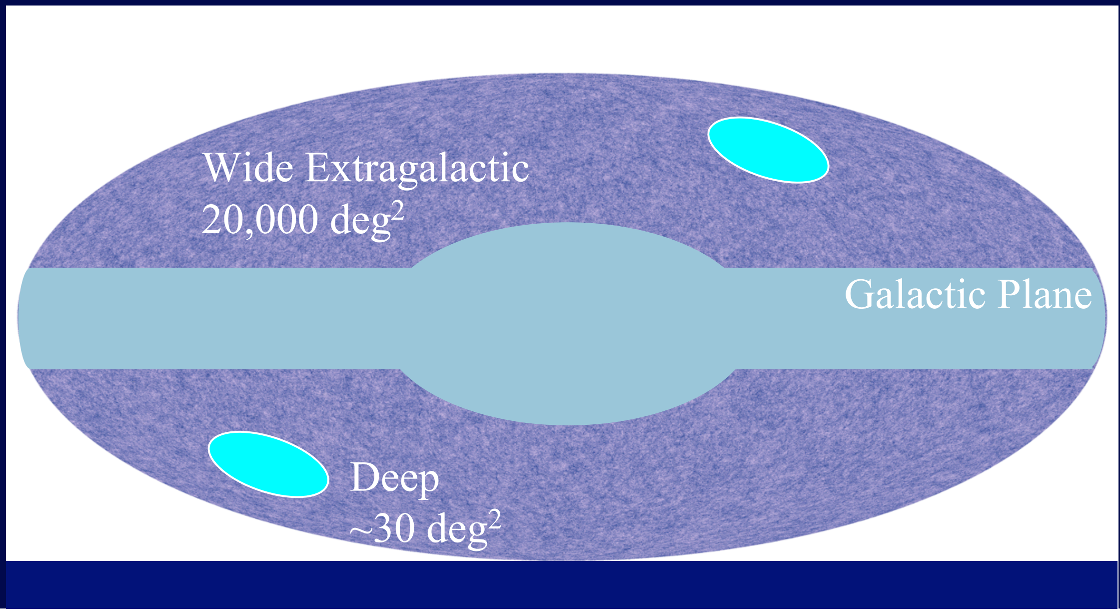
EUCLID

Wide Survey: entire extra-galactic sky (20 000 deg^2)

- Imaging for Weak lensing:
  - Visible: Galaxy shape measurements in R+I+Z<24.5 (AB,10σ), 40 resolved galaxies/amin^2, median resdshift of 0.9
  - NIR photometry: Y,J,H<24 (AB, 5σ PS), photometric redshifts rms 003-0.05(1+z) with ground based complement
- Spectroscopy for BAO:
  - Spectroscopic redshifts for 33% of all galaxies with H(AB)<22 mag, σ_z<0.001

Deep Survey: ~40 deg^2, visible/infrared imaging to H(AB)=26 mag and spectroscopy to H(AB)=24 mag

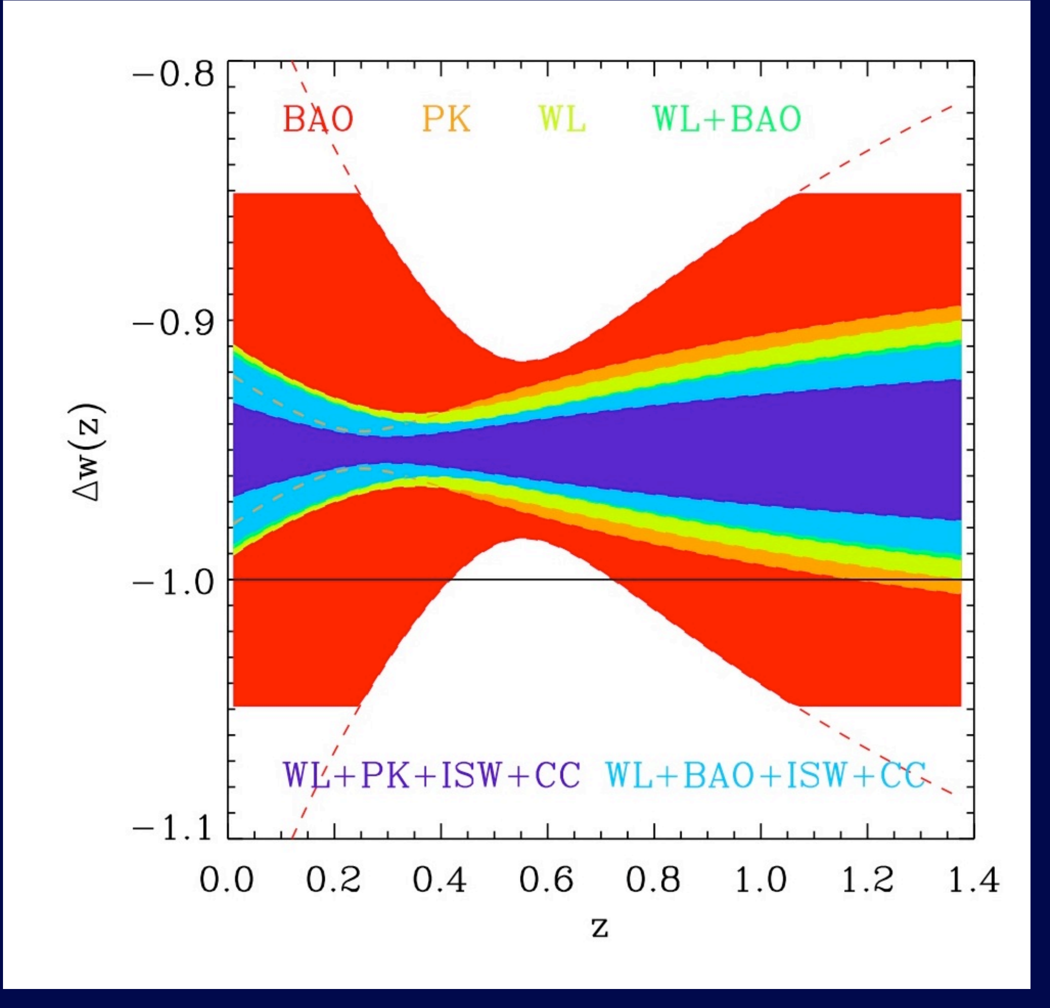
Galactic surveys: Galactic plane and microlensing extra-solar planet surveys under discussion



Horizon Project Simulations, Teyssier et al.

Cosmology and Legacy science

EUCLID



Euclid Cosmology WG

Cosmology:

Measurement of cosmological parameters with unprecedented accuracy

Control of systematics with independent cosmoligical probes

→Measurement of Dark Energy equation of state parameter w and its evolution w' with 1% and 10% accuracy respectively

Legacy:

- Visible/NIR imaging survey: morphologies and vis/NIR colors for billions of galaxies out to z~2, 3D dark matter map
- Spectroscopic survey: 3D map of the luminous matter distribution, spectra of ~200 million galaxies to z~2
- Deep survey: infrared imaging to H(AB)=26 and spectroscopy to H(AB)=24, galaxies with 2<z<7. Objects at z>7 and up to z~10 can be colour-selected from the Y,J,H colours

→ Impossible to reach from the ground

Overall Impact on Cosmology

	DE FoM	Dark Energy			Matter Content		Initial Conditions	
		Δw_n	Δw_a	$\Delta\Omega_v$	$\Delta\Omega_m$	$\Delta\Omega_b$	$\Delta\sigma_8$	Δn_s
WMAP 6	0.13	0.6	13	0.07	0.06	0.008	0.14	0.03
Planck	12	0.03	2.5	0.0036	0.006	0.0009	0.031	0.0037
DUNE	400	0.02	0.12	0.007	0.004	0.1	0.006	0.011
DUNE + Planck	1600	0.011	0.056	0.0018	0.002	0.0006	0.0020	0.0031

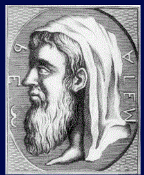
DUNE will challenge all the sectors of the Cosmological model:

- Dark Energy: w_n and w_a with an error of 2% and 10% respectively
- Dark Matter properties: test of CDM paradigm, precision of 0.04eV on sum of neutrino masses (with Planck)
- Initial Conditions: constrain amplitude, slope and higher order parameters of primordial power spectrum, constrain primordial non-gaussianity
- Gravity: Distinguish GR from simplest modified Gravity theories by reaching a precision of 2% on the growth exponent γ ($d\ln\delta_m/d\ln a \propto \Omega_m^{\gamma}$)

→ Goal: uncover new physics

Project Status

- 2004: Wide-field Dark Universe Mission proposed as a *Theme* to ESA's Cosmic Vision programme
- June 2007: DUNE and SPACE proposed to ESA's Cosmic Vision AO as M-class missions
- Oct 2007: DUNE and SPACE jointly selected for an ESA Assessment Phase
- Jan-May 2008: Formation and activities of the Concept Advisory Team (CAT) to define a common mission concept



- May 2008: Validation of the merged concept *Euclid* by the ESA AWG
- May 2008: Formation of the Euclid Science Study team (ESST) to replace CAT
- May-June 2008: Technical study by ESA's Concurrent Design Facility (CDF)
- May 2008: Call for Interest for instrument consortia and Industrial ITT
- Sept 2008-Sept 2009: Industrial assessment study phase
- 2010-2011: Definition phase (if selected)
- 2012-2017: Implementation phase (if further selected)
- 2017: ESA launch of the first Cosmic Vision M-class mission

iCosmo

A. Amara
T. Kitching
A. Rassat
A. Refregier

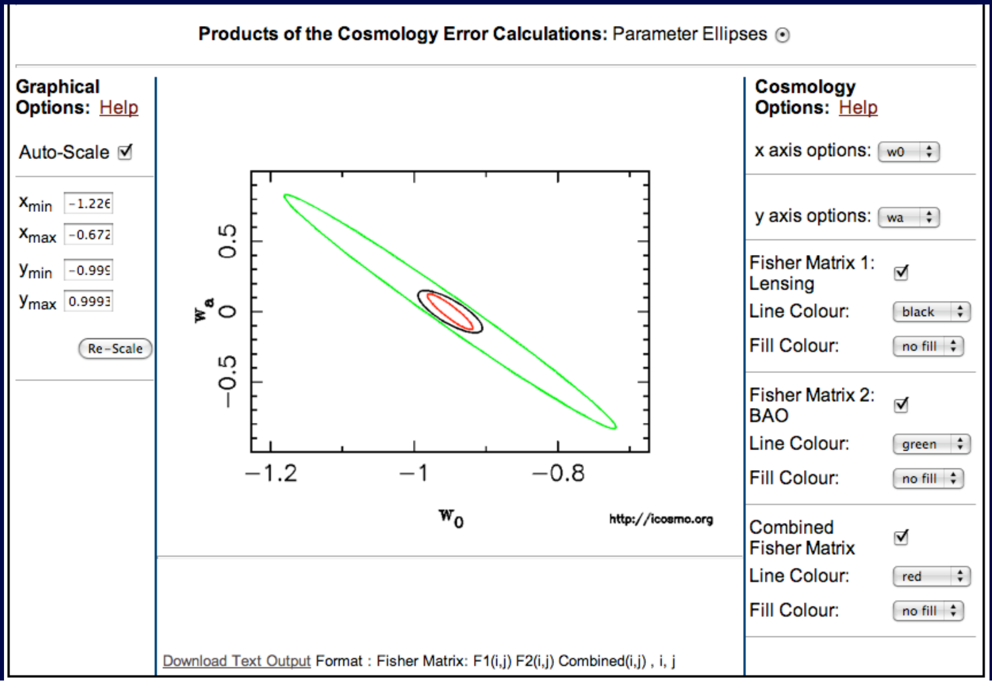
Interactive package for cosmology:

- Freely available interactive IDL code (development platform)
- Interactive web interface
- Web based tutorials and teaching resources

Features:

- Basic quantities: distance scales, growth factor, P(k)
- Observables: BAO, WL, Sne observables
- Parameter constraints: Fisher matrices

→ Can be used to analyse and optimise future surveys



www.icosmo.org

Contributions welcome!

Conclusions

• Dark Universe surveys are the next step for cosmology after Planck: complementary to CMB but different: map the LSS at low redshifts, 3D information, gaussian and non-gaussian, linear and non-linear regime, more data

• Need to measure all fields (potentials, density, velocity) to address all sectors of the cosmological model (DE, DM, MG, IC)

• Wide field Vis/NIR imaging, photometry and spectroscopy are needed and distributed among ground space and space based facilities

• Future missions such as Euclid will provide a 3-dimensional all-sky map of the dark and visible matter in the Universe, set tight constraints on Dark energy (~1% precision on w and ~10% on dw/da) and other cosmological parameters, and producs a wealth of secondary science

• For Dark Universe calculations, check out iCosmo: www.icosmo.org